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Publication number: **0 340 037 B1**

12

EUROPEAN PATENT SPECIFICATION

- 45 Date of publication of patent specification: **27.09.95** 51 Int. Cl.⁶: **B32B 27/06**, B32B 15/08,
H05B 6/64
- 21 Application number: **89304331.5**
- 22 Date of filing: **28.04.89**

54 **Microwave energy susceptible conformable laminate packaging materials.**

- 30 Priority: **29.04.88 US 188556**
- 43 Date of publication of application:
02.11.89 Bulletin 89/44
- 45 Publication of the grant of the patent:
27.09.95 Bulletin 95/39
- 84 Designated Contracting States:
BE CH DE ES FR GB GR IT LI LU NL SE
- 56 References cited:
EP-A- 0 242 952
US-A- 4 267 420
US-A- 4 404 241
US-A- 4 641 005
US-A- 4 713 510

- 73 Proprietor: **E.I. DU PONT DE NEMOURS AND COMPANY**
1007 Market Street
Wilmington
Delaware 19898 (US)
- 72 Inventor: **Fong, Dan Shau Cheong**
3 Chapel Crest
Wilmington
Delaware 19810 (US)
- 74 Representative: **Jones, Alan John et al**
CARPMAELS & RANSFORD
43 Bloomsbury Square
London, WC1A 2RA (GB)

EP 0 340 037 B1

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DescriptionBACKGROUND OF THE INVENTION

5 This invention relates to packaging materials and structures used in microwave cooking, and specifically to microwaveable packaging of food items which require surface browning and/or crispening during cooking.

There has been much interest recently in packaging materials which aid in browning and crispening of food items in a microwave oven. U.S. Patent 4,267,420, Brastad, discloses a food item wrapped with plastic film having a very thin coating thereon. An additional sheet or film of plastic is optionally laminated to the coating for abrasion protection. Other exterior support by more rigid dielectric materials such as paperboard and the like is also disclosed. The coating converts some of the microwave energy into heat which is transmitted directly to the surface portion of the food so that a browning and/or crispening is achieved.

10 U.S. Patent 4,641,005, Seiferth, discloses a disposable food receptacle for use in microwave cooking, which includes a provision to brown the exterior of the food in the receptacle. A thin layer of an electrically conductive material is incorporated into the receptacle on the food contacting surfaces thereof, so that the conductive layer will become heated by the microwave radiation and will, in turn, brown the exterior of the food in the receptacle. The receptacle includes a smooth surfaced plastic film, as a protective layer, and a support means formed of paper stock material.

15 U.S. Patent 4,713,510, Quick et al., discloses a microwave ovenable package including a layer of material that will convert a portion of the microwave energy to heat and a layer of paperboard interposed between the energy-converting layer and the food. The energy-converting layer may be carried on a plastic film, and an additional layer of paperboard may be used to sandwich the energy-converting layer and the plastic film between layers of paperboard. For the purpose of providing a more intense heating effect, two energy-converting layers, each on a dielectric substrate, sandwiched together between layers of paperboard, are disclosed.

20 Laminates of plastic films with thick layers of vacuum deposited metal are also known as packaging materials. For Example, U.S. Patent 4,559,266, Misasa et al., discloses a laminated material comprising (A) a layer composed mainly of polyolefin, (B) a layer composed mainly of, e.g., polyester resin, (C), a metal-vacuum deposited layer, and (D) a layer composed mainly of a transparent thermoplastic resin. This laminated material is used for its superior gas barrier properties and light shielding properties, etc. Such laminates, in order to provide significant gas barrier properties for packaging applications, require deposition of metal (typically aluminum) in sufficient amounts to impart optical densities of greater than 1.0, typically at least 4.0. Such materials are substantially opaque and have light shielding properties, but are not suited for use for microwave heating applications, for which much lower optical densities are required.

25 In order properly to brown or crisp foods which are irregular in shape or which have nonplanar surfaces, it is desirable to have a packaging material which is readily conformable to the food. It is also desirable that the material supply enough heat energy to the surface of the food, and provide some degree of microwave shielding for the interior of the food so that the surface can be properly browned or crispened in a short time without the interior becoming overcooked. The present invention provides a laminar film which conforms closely to the shape of a food item during cooking, provides a high degree of heat to the surface of the food, and provides shielding to the interior portion.

SUMMARY OF THE INVENTION

30 The present invention provides a conformable multilayer laminated structure useful for packaging food for microwave cooking, comprising:

- (a) at least one layer of flexible microwave transparent plastic film consisting essentially of polyethylene terephthalate and which withstands a temperature of about 220 °C without melting or degrading;
- (b) at least one layer of flexible microwave transparent plastic film consisting essentially of heat stable polyethylene terephthalate and which withstands a temperature of about 220 °C without melting or degrading which film further exhibits less than 0.6% shrinkage when exposed for 30 minutes to a temperature of 150 °C; and
- (c) at least one layer of substantially continuous microwave susceptor material located on a surface of a film of the laminate, said layer being located between film (a) on one side and film (b) on the other side, and being present in sufficient thickness to cause the multilayer structure to heat under microwave cooking conditions to a temperature suitable for browning or crispening of food placed adjacent thereto.

35 The present invention also provides packages suitable for containing food and browning or crispening of the surface of food in a microwave oven prepared from such film.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a cross sectional detail of a laminated structure of this invention.

Figure 2 shows a cross sectional detail of another laminated structure of this invention.

5 Figure 3 shows an alternative embodiment which includes two layers of susceptor material.

Figure 4 shows an embodiment of the multilayered structure of this invention containing a plurality of slits.

Figure 5 shows the structure of Figure 4 after microwave irradiation.

10 Figure 6 and Figure 7 show the internal heating curves for food items packaged with the structures of the present invention and with comparative packages.

Figure 8 shows a mold assembly suitable for conforming the laminated film of the present invention to the crust of a deep dish pizza.

Figure 9 shows a package of the present invention.

15 DETAILED DESCRIPTION OF THE INVENTION

The present invention consists of a multilayered structure having at least two layers of heat resistant microwave transparent plastic film, and at least one substantially continuous layer of microwave susceptible material. This microwave susceptible material is coated on at least one of the interior surfaces or interfaces formed between the plastic films of the laminate.

20 The susceptor material is a substantially continuous electrically conductive material which is present in sufficient thickness to cause the multilayer structure to heat under microwave cooking conditions to a temperature suitable for browning or crispening of food placed adjacent thereto, but not so thick as to completely prevent penetration of microwave energy to the interior of the food. A preferred susceptor material is vacuum metallized aluminum, which will preferably be present in sufficient amounts to impart an optical density of about 0.10 to about 0.35, preferably 0.16 to about 0.22, to the film. Other metals, of course, may be used, including gold, silver, mu-metal, nickel, antimony, copper, molybdenum, bronze, iron, tin, and zinc. Although the optical density may vary with the metal used, the test to determine the correct amount of coating is whether the coating will heat to the proper temperature and provide sufficient heat flux for browning or crispening of food items. The required temperature may depend on the particular food item used, but for many applications, it is at least about 180 °C. The thin layer of susceptor material is preferably imparted to the film surface before lamination by vacuum metallizing. Other methods may also be used if they provide a substantially continuous layer of the desired thickness.

35 The layer of susceptor material is coated onto at least one surface of heat resistant, microwave transparent plastic film. This film may be made from any suitable plastic film which has the desired properties of heat resistance and microwave transparency. The term "heat resistant" refers to the ability of the film to withstand the temperatures generated in a 700 watt microwave oven during cooking without melting or degrading. When the film is made into the laminate of the present invention, as will be shown, temperatures of up to about 220 °C or more may be encountered under microwave cooking conditions, so the film should maintain its integrity at such temperatures. Polyethylene terephthalate (PET), having a melting point of about 260 °C, is used for this purpose.

45 The layer of film on which the thin layer of microwave susceptor is located should have at least a moderate degree of resistance to deformation or shrinkage upon heating. Ordinary PET film (as opposed to shrink film) is suitable for use as this layer because it shrinks only about 1.5 to 3% at 150 °C over a period of thirty minutes. However, ordinary PET by itself does tend to shrink more than this amount under the intense heat encountered in a microwave oven when the film is coated with susceptor material. Excessive shrinkage observed under such conditions, of up to 60%, is not desirable because many foods, such as breads, can be crushed by the action of a such a film. Furthermore, excessive shrinkage tends to disrupt continuity of the layer of susceptor material, thereby degrading the heating properties.

50 In order to provide a controlled amount of shrinkage, this invention provides that at least one layer of film in the laminate should be a heat stable film. The term "heat stable" refers to film which exhibits only a minimal amount of shrinkage at elevated temperatures. The film which is used is heat stabilized PET which typically shrinks less than 0.6% in thirty minutes at 150 °C. Heat stabilized PET is made from a regular grade of PET film by a stabilization process involving a series of heat treatment and relaxation steps, and is well known to those skilled in the art. A heat stabilization process for PET is more fully described in Bulletin E-50542, "Thermal Stabilization of Mylar®," from E. I. Du Pont de Nemours and Company.

55 In its simplest form, the invention contemplates use of a single layer of heat stable film in combination with a single layer of ordinary heat resistant film. These layers provide not only a support or substrate for

the susceptor but also serve to protect the layer of susceptor and to provide a heat sink to prevent overheating of the film. The laminate results in improved dimensional stability and improved heating characteristics of the laminate, as described below. The thickness of the layer or layers of the heat stable film is not precisely limited. However, the thickness of the heat stable film should be sufficient to impart a degree of dimensional stability to the laminate. It is desired for the reasons discussed above that the shrinkage of the laminate, in any direction, be limited and controlled, preferably no greater than about 20 percent upon exposure to the energy of a microwave oven. It is more preferred that the shrinkage obtained will be no greater than about 15 percent, and a shrinkage of about 10 percent is most desirable. It has been found that for laminates comprising a single layer of PET, 0.013 mm thick, a single layer of heat stabilized PET about 0.013 mm thick is adequate to provide this limited degree of shrinkage. It is preferred, however, that at least two layers of heat stable film be used, one layer on either side of the thin layer of microwave susceptor material.

Laminates prepared using heat stabilized PET provide superior results compared with known laminates in which the outer layers are paper or paperboard. Laminates with paperboard do not generally exhibit the improved heating properties found in the present invention, and are not conformable, transparent, or particularly flexible.

Other layers may be present in the laminate for particular purposes. For example, the susceptor layer can be deposited on a layer of ordinary PET film, which in turn is laminated between two layers of heat stabilized PET, one on either side of the layer of ordinary (heat resistant) PET. In addition, one or more adhesive layers may be used to bond the layers of the laminate together. The adhesive may be any known to those skilled in the art to be suitable for such purposes. In addition, one or more layers of a heat sealable thermoplastic resin may be used as surface layers, overlying the heat stable plastic layers. Such layers may be useful for sealing the film to itself or to other items, for packaging applications. Suitable heat sealable thermoplastic resins are known in the art; particularly suitable resins are polyesters selected from the group consisting of copolymers of ethylene glycol, terephthalic acid, and azelaic acid; copolymers of ethylene glycol, terephthalic acid, and isophthalic acid; and mixtures of these copolymers.

Figure 1 shows a simple embodiment of a laminate of this invention. There are two layers of flexible, heat resistant, microwave transparent film, 10 and 12, at least one of which is heat stable film. A layer of susceptor material, 14, such as vacuum metallized aluminum, is located on an interior surface of film 12. There is also an adhesive layer, 16, used to join the layers of film together in the laminate.

Figure 2 shows an alternative embodiment of this invention. The top layer, 18, is a layer of heat sealable resin, which overlies a layer of flexible, heat resistant, microwave transparent plastic film, 20. Layers 22 and 24 are adhesive resins. Under the first layer of plastic film 20 is a central layer of film, 26, with a coating of susceptor material, 28. Laminated to the other surface of the central film is another outer layer of plastic film, 30. Either film layer 20 or 30, or preferably both, are heat stable. The central layer, 26, may also be of heat stable film, if desired, although this is not required.

Figure 3 shows another embodiment, in which there are two internal susceptor layers, 32 and 34, located on two adjacent layers of plastic film, 36 and 38. The layers of plastic film which carry the susceptor material are laminated front to back, so that the susceptor layers are separated by the thickness of one layer of plastic film. The upper layer of susceptor material is protected by an outer layer of plastic film 40 which overlies it. The layers of film are held together by adhesive layers 42 and 44. The upper layer of film, furthermore, is overlain by a layer of heat sealable resin, 46. At least one layer 36, 38, or 40 is heat stable film, and preferably at least the two outer layers, 38 and 40 are heat stable film. The embodiment illustrated by this figure provides additional heating ability, and also additional microwave shielding, compared with that of Figure 2, because of the additional layer of susceptor material. The presence of multiple layers of susceptor material results in an increased optical density, when the susceptor material is, for example, aluminum. The heating ability of such multiple layer heaters is improved somewhat when the layers of susceptor material are separated from each other as shown, i.e., when the films on which they are carried are not laminated together face to face. It is also permissible, therefore, when multiple layers of susceptor material are used, that one layer be located on each of the two surfaces of the central layer of plastic film. Alternatively, the susceptor material may be on the interior surfaces of the outer layers of film. In such arrangements both layers of susceptor material are covered by an outer layer of film and remain separated by the thickness of the central layer of film. It is apparent that many similar arrangements of film and susceptor layers are permissible within the scope of this invention.

The multilayer laminates of this invention have several advantages over monolayer metallized films. The first advantage is that these laminates provide a significantly higher heat flux than do the single layer, susceptor coated films. This is important because heat flux is a measure of the ability of the laminate to rapidly heat the surface of the food with which it is in contact. The reasons for this improvement are not

clearly understood. It is believed, however, that the additional layers of film provide additional support and protection during heating for the susceptor layer. This support, then, prevents "mud cracking," or breaking up of the susceptor layer into small islands upon exposure to microwave radiation. Such cracking of the susceptor layer is believed to reduce the efficiency of the heating. This improvement in heating efficiency is illustrated in the examples which follow.

Another advantage is observed when films of the present invention are used to heat food items. It has been found that the interior of food items heats somewhat more slowly when the food is wrapped in films of the present invention, compared with single layer films. Thus the films provide an added measure of shielding to the interior of the food, further aiding the cooking by preventing overcooking of the food interior while the surface is being browned and crispened.

Yet another advantage of having the susceptor layer buried between other film layers is that the cover layer protects the film from oxidation or corrosion by the air. When a thin layer of aluminum on PET film was exposed to the air for seven months, the optical density was observed to decrease from an initial value of 0.23 to 0.18. Another sample, held at 38 °C and 90% relative humidity for 14 days decreased in optical density from 0.17 to 0.15, and developed streaks, while a comparable film laminated to a film of PET remained unchanged.

One of the most significant advantages of the present invention is that the presence of at least one layer of a heat stable film such as heat stabilized PET, provides a laminate which exhibits controlled shrinkage. Although the PET used is not a shrink film, single layers of microwave susceptor films under microwave conditions shrink and degrade or form holes. Even multiple layer structures may show excessive shrinkage, of up to about 60 %, under microwave conditions, if at least one heat stable film layer is not used. When heat stabilized PET is used as at least one layer, and preferably two outer layers, however, the shrinkage is controlled to about 10 %. This level of shrinkage is necessary for many applications, in order to permit the film to retain a snug configuration about the item of food to be cooked. Thus packages made of the laminates of the present invention will shrink just enough to achieve or maintain conformity about the food item, without crushing it. Such behavior is particularly desirable for packaging of such fragile items as bread. The conformity with the surface of the food item permits efficient transfer of heat energy from the film to the food surface, for efficient browning or crispening of the food.

The controlled shrinkage, furthermore, results in structures which do not exhibit large scale nonuniform deterioration, such as holes, developing upon heating in a microwave oven. Such deteriorations or other distortions are observed when single layer, susceptor coated films that are not heat stable are used for wrapping foods for microwave cooking. These deteriorations prevent the film from conforming to the shape of the food, and thus prevent uniform cooking.

It is also possible to take advantage of the limited shrinkage of the laminates prepared with heat stabilized PET in a different manner. Figure 4 shows a sheet of such film 48 containing slits 50 piercing through the thickness of the film. These slits may be covered by a label affixed by pressure sensitive adhesive (not shown) during storage, which is removed before cooking. Upon microwave treatment, the slits open to form the openings 52 shown in Figure 5. A laminate containing one or more such openings may be useful for venting of vapor from the food item during cooking.

Comparative Examples C1-C3

Comparative Examples C1-C3, reported in Table I, show some of the properties of single layers of PET, not heat stabilized, metallized with aluminum. Films B, C, and D are films of polyethylene terephthalate, 0.013 mm thick (0.5 mils, 50 gauge) which have been vacuum metallized with aluminum to the optical density indicated.

The shrinkage of these film upon exposure to a 700 W microwave field for 10 seconds is also reported in Table I. For such measurements, A strip of film, 127 mm x 25 mm, is clamped in a holder assembly made of polytetrafluoroethylene. One end of the film is attached to a clamp rigidly mounted onto the base of the holder assembly. The other end of the film is attached to a clamp which is mounted on the base. As the film heats, shrinkage of the film moves the slidably mounted clamp along a scale so that the relative amount of shrinkage can be measured by comparing the position of the clamp before and after heating. Tests are reported of samples in which the long dimension is in the machine direction as well as in the transverse direction. During such tests, these single layer films fail mechanically by formation of holes. This mechanical failure results in the anomalously low measurements of shrinkage for these single layer films, as reported in Table I. (This hole formation is suggestive that the films, without the presence of additional layers of film or contact with the surface of a food item to act as a heat sink, may heat in this test to above the melting point of the PET, which is about 250-260 °C.)

The heating parameters for the films are shown in Table I. The maximum temperature and heat flux are determined by measuring the heat rise of a sample of oil. The oil, 5 g of microwave transparent oil (Dow-Corning 210H heat transfer silicon oil), is placed in a Pyrex™ borosilicate glass tube, 125 mm long, 15 mm outside diameter. A sample of film to be tested, 46 X 20 mm, is wrapped around the tube, with the long dimension of the film along the length of the tube and the top edge of the film located at the level of the surface of the oil. The film sample is secured by use of microwave transparent tape prepared from polytetrafluoroethylene, about 6 mm larger than the film sample, and the tube assembly is supported in a holder also of polytetrafluoroethylene. The temperature rise of the oil upon heating the assembly in a microwave oven is measured at 15 second intervals using a "Luxtron" temperature probe placed in the oil sample and connected to suitable recording instrumentation. Maximum heat flux is taken from the plot of oil temperature versus time, and is reported as the slope of a straight line originating at time = 0 minutes and terminating at the time which gives the greatest slope, normally about 1 minute. The values so obtained are often approximately 2/3 of the maximum instantaneous increase in oil temperature as a function of time.

Examples 1-5 and Comparative Examples C4-C13

Examples 1-5 and Comparative Examples C4-C13, in Table I, show the properties of various multiple layer laminated film structures. The structure of these films is shown schematically. One layer (B, C, or D) is a layer of polyethylene terephthalate metallized with aluminum, as in Comparative Examples C1-C3. The metallized film is laminated to at least one other layer of film, using a layer of adhesive, "Adcote" 506-40 (crosslinkable copolyester, from Morton Thiokol). After lamination the laminate is stored, rolled on a paper core for at least three days, and normally 7 to 14 days at room temperature in order to ensure complete curing of the adhesive. The substrate is either paper (parchment, 0.13 mm, 5 mils) or polyethylene terephthalate film. The PET film is indicated in the Table by the letter "H" for heat stabilized PET film, or by the letter "P" for PET film which was not heat stabilized. The thickness of the PET film substrate is about 0.012 mm or about 0.023 mm, indicated by the numbers "48" (48 gauge) or "92" (92 gauge), respectively. In some cases the PET films are also coated with a layer of heat sealable polyester resin, located on the outer surface. This heat sealable layer is the condensation product of 1.0 mol ethylene glycol with 0.53 mol terephthalic acid and 0.47 mol azelaic acid, also containing small amounts of erucamide and magnesium silicate. This layer is indicated in the Table by the plus (+) symbol. It is seen from Comparative Examples C4, C5, C9, C11, and C12 that the laminates in which the films are not heat stable tend to exhibit excessive shrinkage upon heating in a microwave oven, evidenced by excessive MD or TD shrinkage, and exhibiting significant variability among samples. When at least one film of the laminate is heat stabilized PET, however, the shrinkage is much less and much more uniform and predictable.

The laminates of the present invention, furthermore, show improved temperature and heat flux characteristics compared with the single layer films, when the susceptor layer is located in the interior of the laminate. (See Example 1 and Comparative Example C2.) When the susceptor layer is located on an outer surface of the laminate, however, there is no improvement in heat flux. (Comparative Examples C6, C7, and C8.) When paper, rather than film, is used to prepare the laminate (Comparative Examples C10 and C13) there is no significant improvement in heating properties compared with single films. It should be noted that laminates which exhibit larger heat flux would, because of the higher temperatures generated, tend to shrink more than would structures exhibiting lower heat flux, independently of the composition of the film layers. This factor should be taken into account when comparing shrinkage values.

Example 6 and Comparative Examples C14-C20

These examples are prepared by laminating two layers of aluminized film, as indicated. In Comparative Examples C14 and C16 the layers of metal are adjacent, separated only by a layer of adhesive. In Example 6 and Comparative Examples C15 and C17 the layers of metal are separated by the thickness of the PET layer. In the examples where two layers of susceptor coating are separated by a layer of film, further improvement in heating efficiency is seen. This result permits a film structure such as that of Example 6 to be used for the microwave cooking of certain food products, such as pizza or bread, which require a high surface heat, but where the interior of the product requires a degree of shielding to prevent overcooking.

TABLE I

Ex	Composition	OD	% Shrink		Max T	Max Flux
			MD	TD	(°C)	(kcal/ m ² -min)
5	C1	B*	0.13	8	15 ^C	
	C2	C*	0.16	7	8 ^C	181 133
	"	"				140 68
10	"	"	0.19			183 108
	"	"				167 93
	"	"				180 116
	C3	D*	0.18	7	8 ^C	
	"	"	0.28	4	5 ^C	
15	"	"	0.23			87 28
	"	"				73 21
	"	"				90 33
	C4	B*/48P+	0.14	5	38	
	C5	C*/48P+	0.17	29	48	202 175
20	C6	*C/48P+	0.18			168 116
	C7	*C/48H	0.19	14	3	128 59
	"	"				174 105
	1	C*/48H+	0.14	10	9	205 186
	"	"	0.16	a	7	188 160
25	"	"		a	a	184 145
	C8	*D/48H	0.21	5	2	178 106
	"	//				171 101
	C9	D*/48P+	0.25	10	4	
	2	D*/48H+	0.19	8 ^b	4 ^b	193 160
30	"	//				192 170
	C10	C*/Paper				175 143
	C11	48P/C*/48P+	0.15	55	60	212 200
	C12	92P/C*/48P+	0.16	30	25	206 195
	3	48H/C*/48H				206 222
35	4	48H/C*/48H+	0.16	8	8	212 189
	"	"	0.17	18	6	201 148
	"	"				200 150
	5	48H/D*/48H+	0.19	5	7	200 171
	"	"				191 140
40	C13	Paper/C*/Paper				161 115

45

50

55

Table I, continued

5	C14	C*/*D #	0.34	a	a	195	199
						199	190
	C15	C*/D* #	0.38	a	7	215	230
						213	221
	C16	D*/*C/48P+	0.35			197	195
	C17	D*/C*/48P+	0.35			213	214
10	6	48H/C*/D*/48H+ #	0.34	16	14	213	218
						213	217
	C18	*D/92P+/*C #	0.37	20	22	210	187
						216	194
	C19	*D/48P+/*C #	0.40	20	22	201	199
15						204	199
	C20	Paper/C*/C*/Paper				200	197

* : indicates location of susceptor layer.

+ : indicates location of heat sealable polyester layer.

a : sample broke.

b : a duplicate measurement, believed to be in error, showed 45 and 50% for MD and TD, respectively.

c : samples developed holes during test.

Example 7

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Loaves of Italian bread (454 g) were purchased from a local supermarket packaged in white paper bags. They were stored for two days, some in their original bags, and some sealed in pouches formed from composite film of similar to that of Example 4. The pouch was reasonably transparent, permitting a good view of the bread. After two days storage, the unwrapped samples were hard and stale. (See Table II.) Both the unwrapped and the wrapped samples were heated for two minutes in a 700 watt microwave oven. Only the loaves sealed in the susceptor pouches were properly restored. (Properly restored loaves have a crisp, dry crust, but an interior which is not dry, but slightly moist, and not tough.) During the microwave heating process, the pouches shrank somewhat by "microwrinkling" around the bread to give a snug fit. (Since the loaves were too long to use a turntable, browning and crisping was not completely uniform.) Internal temperature of the loaves was measured using "Luxtron" probes, and recorded as a function of cooking time, shown in Table III.

35

40

TABLE II

45

PERCENT WEIGHT LOSS		
	Unwrapped	In Pouches
1 day	6	negligible
2 days	11	0.2
after microwave heating	15	1.7

50

55

TABLE III

Time (sec)	Temperature, °C	
	Unwrapped	Poucht
0	20	21.5
15	32	26
30	45	30.5
45	66	35
60	88	40.5
75	100	47
90	102	52.5
105	103	62
120	103	66

† Average of two loaves heated. Deviation from the average temperature did not exceed $\pm 7C^\circ$.

It is believed that the fact that the internal temperature in the wrapped sample did not quickly rise to the boiling point is important to successful reconstitution of the bread. This difference is believed to result from the shielding effect of the low microwave transmission of the film used.

Example 8

Three frozen egg rolls (La Choy™, "Almond Chicken" filling) weighing about 120 g, about 127 mm long and about 38 mm diameter were cooked in a microwave oven as in Example 7, for 4 minutes. Sample A was cooked without any susceptor wrapping. Sample B was wrapped in a single layer metallized PET having an optical density of 0.16 (film C in Comparative Example C2). The wrapping was sealed with a polyimide based tape. Sample C was wrapped and sealed with a film similar to that of Example 4. The results are shown in Table IV and Figure 6.

TABLE IV

Time (min)	Temperature, °C		
	A unwrapped	B monolayer	C laminate
0.00	0	0	0
1.00	5	0	0
1.25	98	0	5
1.50	100	5	10
2.00	100	35	28
3.00	100	90	68
3.50	100	100	85
4.00	100	100	100

Desirable serving temperature for most hot foods is 70°C. The desired cooking period for frozen egg rolls is about 3 minutes, in order to obtain the best browning. Only the package of this invention (C) meets these requirements. Both of the other two egg rolls were overdone, the unwrapped one (A) especially so. The unwrapped egg roll, in addition, was soft and soggy on the outside. It is believed that the favorable results from package C derive in large part from reduced transmission of microwaves to the bulk of the food item and increased shielding provided by the laminate, compared with the monolayer film.

Example 9

Example 8 was repeated, using instead of the egg rolls, fresh "steak" rolls. The results are shown in Table V and Figure 7. As in Example 7, the unwrapped roll did not attain surface crispness and was internally overcooked. The results also show that the laminate of this invention (C) provides greater

shielding of the interior of the food item than does a monolayer structure (B).

TABLE V

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10
15

Time (sec)	Temperature, °C		
	A unwrapped	B monolayer	C laminate
0	24	22	20
5	28	28	23
10	47	47	33
15	79	67	47
20	102	86	60
25	103	92	74
30	103	102	83
35	103	103	88

Example 10

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Two frozen dinner rolls, 150 mm long x 64 mm diameter were cooked separately in a 700 watt microwave oven. The first was cooked unwrapped, as removed from the store package, as a control. The second was sealed in a pouch of film as in Example 7. After 60 seconds of heating, the unwrapped sample was soft on the outside and steaming on the inside (about 93 °C). The wrapped sample, after 65 seconds of heating, was crispy and brown on the outside and properly hot (about 70 °C) on the inside.

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Example 11

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This example shows a packaging configuration other than a pouch. A round deep-dish pizza was packaged and cooked in a package made from the laminate of this invention. A 185 mm square piece of susceptor film as in Example 4 was conformed to the bottom and sides of the crust of the pizza by use of a mold assembly shown in Figure 8. The mold assembly 54 contained a round cavity, 56 about 134 mm in diameter and 33 mm deep, a suitable size for containing the pizza. The film was placed over the cavity and pressed into the cavity by ram 58, so that the film conformed to the cavity, and wrinkles were pressed into place. The ram was removed and the pizza, frozen, weighing 184 g, 127 mm diameter, 25 mm height, was placed into the formed film. The excess film was trimmed even with the edges of the mold assembly. A cover sheet of 9 micrometer (35 gauge) aluminum foil laminated to 0.13 mm (5 mil) parchment paper was heat sealed to the film (by means of the heat sealable layer) to act as a shield over the top of the pizza. A diagram of the packaged pizza is shown in Figure 9. The pizza with crust, 60, and filling, 62, is held within the laminated film, 64. The cover sheet, 66, is sealed to the lower, laminated film, 64, to form a circumferential rim, 68. The packaged pizza was removed from the mold cavity and cooked in a 700 watt oven with a turntable for 3 minutes and 45 seconds. The bottom and sides of the crust were crisp and brown, and the filling was hot but not overcooked. The crisp, stiff crust provided good shape and integrity for the pizza.

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Comparative Example C21

An identical pizza was cooked in its original open ended plastic bag under the same conditions as Example 11. No browning or crispening of the crust was apparent. The crust, rather, was wet and soggy and the topping messy. The pizza itself was floppy and had poor shape integrity.

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Examples 12 and 13

Laminated samples of films having multiple layers of heat stabilized PET are prepared by the procedure described for Example 1. The heating and shrinkage results from tests on these films are presented in Table VI, wherein the designation of the layers is the same as that used in Table I. The presence of additional layers of heat stabilized PET provides additional structural stability and avoids the problem of breakage occasionally encountered when a single layer of such film is used (see Example 1).

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TABLE VI

Ex	Composition	OD ^a	% Shrink		Max T (°C)	Max Flux (kcal/m ² -min)
			MD	TD		
12	C*/48H + /48H	0.16	20	16	190	246
	"				199	197
13	C*/48H + /48H/48H	0.16	25	12	203	176
	"				200	178

a : Optical density taken from the measurement of the film of Example 1, from which the present films were prepared.

Claims

1. A conformable multilayer laminated structure useful for packaging food for microwave cooking, comprising:
 - (a) at least one layer of flexible, microwave transparent plastic film prepared from polyethylene terephthalate and which withstands a temperature of about 220 °C without melting or degrading;
 - (b) at least one layer of flexible microwave transparent plastic film prepared from heat stable polyethylene terephthalate and which withstands a temperature of about 220 °C without melting or degrading which film further exhibits less than 0.6% shrinkage when exposed for 30 minutes to a temperature of 150 °C; and
 - (c) at least one layer of substantially continuous microwave susceptor material located on a surface of a film of the laminate, said layer being located between film (a) on one side and film (b) on the other side, and being present in sufficient thickness to cause the multilayer structure to heat under microwave cooking conditions to a temperature suitable for browning or crispening of food placed adjacent thereto.
2. The multilayer structure of claim 1 wherein the thickness of film (b) is at least about 0.013 mm.
3. The multilayer structure of either of claims 1 and 2 wherein the microwave susceptor material is vacuum deposited metal.
4. The multilayer structure of any one of claims 1 to 3 further comprising at least one surface layer of heat sealable thermoplastic resin.
5. The multilayer structure of any one of claims 1 to 4 wherein at least one slit pierces the structure.
6. The multilayer structure of any one of claims 1 to 5 wherein film (a) is also heat stable.
7. The multilayer structure of any one of claims 1 to 6 wherein the layer of susceptor material is located on the surface of a third flexible heat resistant, microwave transparent plastic film, located between films (a) and (b).
8. The multilayer structure of any one of claims 1 to 6 wherein there is a plurality of layers of substantially continuous microwave susceptor material, said layers being separated from each other by at least one layer of flexible, heat resistant, microwave transparent plastic film.
9. A package suitable for containing food and browning or crispening the surface of food in a microwave oven comprising the multilayer structure of any one of claims 1 to 8 wrapped about the food.
10. A package suitable for containing and cooking a food item which requires browning or crispening of bottom and side surfaces and shielding of its top surface, said package comprising
 - (a) a bottom portion conformed to the bottom and side surfaces of the food item, extending to the level of the upper surface of the food item, said bottom portion comprising the multilayer structure of

claim 4; and

(b) a substantially microwave reflecting cover, said cover being at least partially sealed to the bottom portion of the package, thereby forming a space to contain the food item.

- 5 **11.** The package of claim 10 wherein the film of the bottom portion forms a radial flange about the circumference of the food item near level of the upper surface of the food item, and the cover is sealed to the flange.
- 12.** A process for cooking food, comprising placing the package of claim 9, 10 or 11 in a microwave oven
10 and operating the oven for a sufficient time to achieve the desired browning, crispening, and cooking of the food.

Patentansprüche

- 15 **1.** Formbarer, laminiertes Mehrschichtstoff, geeignet zur Verpackung von Nahrungsmitteln zum Garen durch Mikrowellen, umfassend:
- (a) mindestens eine Schicht aus einer flexiblen, für Mikrowellen durchlässigen Kunststoffolie, hergestellt aus Polyethylenterephthalat, die eine Temperatur von etwa 220 °C aushält, ohne zu
20 schmelzen oder sich zu zersetzen;
- (b) mindestens eine Schicht aus einer flexiblen, für Mikrowellen durchlässigen Kunststoffolie, hergestellt aus wärmebeständigem Polyethylenterephthalat, die eine Temperatur von etwa 220 °C aushält, ohne zu schmelzen oder sich zu zersetzen, wobei die Folie des weiteren weniger als 0,6 % Schrumpfung aufweist, wenn sie 30 Minuten lang einer Temperatur von 150 °C ausgesetzt wird; und
25 (c) mindestens eine Schicht aus im wesentlichen kontinuierlichem, mikrowellenenergieempfindlichem Material, das auf einer Oberfläche einer Folie des Mehrschichtstoffs angeordnet ist, wobei die Schicht zwischen der Folie (a) auf einer Seite und der Folie (b) auf der anderen Seite angeordnet ist und in einer so großen Dicke vorhanden ist, daß sich der Mehrschichtstoff unter den Garungsbedingungen durch Mikrowellen auf eine Temperatur erhitzt, die geeignet ist, ein nahe an diesem befindliches Nahrungsmittel zu bräunen oder knusprig zu machen.
- 30 **2.** Mehrschichtstoff nach Anspruch 1, worin die Dicke der Folie (b) mindestens etwa 0,013 mm beträgt.
- 3.** Mehrschichtstoff nach jedem der Ansprüche 1 und 2, worin das mikrowellenenergieempfindliche Material ein vakuumaufgedampftes Metall ist.
- 35 **4.** Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 3, des weiteren umfassend mindestens eine Oberflächenschicht aus einem heißversiegelbaren thermoplastischen Harz.
- 5.** Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 4, worin mindestens ein Schlitz durch den
40 Stoff hindurch eingebracht ist.
- 6.** Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 5, worin die Folie (a) ebenfalls wärmebeständig ist.
- 45 **7.** Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 6, worin die Schicht aus empfindlichem Material auf der Oberfläche einer dritten flexiblen, wärmebeständigen, für Mikrowellen durchlässigen Kunststoffolie angeordnet ist, die zwischen den Folien (a) und (b) angeordnet ist.
- 8.** Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 6, worin eine Vielzahl von Schichten aus
50 im wesentlichen kontinuierlichen, mikrowellenenergieempfindlichen Material vorhanden ist, wobei die Schichten voneinander getrennt sind durch mindestens eine Schicht aus einer flexiblen, wärmebeständigen, für Mikrowellen durchlässigen Kunststoffolie.
- 9.** Verpackung, in der Nahrungsmittel aufgenommen werden können und die Oberfläche der Nahrungsmittel
55 in einem Mikrowellenherd gebräunt oder knusprig gemacht werden kann, umfassend den Mehrschichtstoff nach einem beliebigen der Ansprüche 1 bis 8, der um das Nahrungsmittel herumgewickelt wird.

10. Verpackung, in der ein Nahrungsmittel aufgenommen und gegart werden kann, dessen untere Fläche und Seitenflächen gebräunt oder knusprig gemacht werden sollen und dessen obere Seite abgeschirmt werden soll, wobei die Verpackung umfaßt:

5 (a) einen Bodenabschnitt, der an die untere und die Seitenflächen des Nahrungsmittels angeformt wird und sich bis zur Höhe der oberen Fläche des Nahrungsmittels erstreckt, wobei der Bodenabschnitt aus dem Mehrschichtstoff nach Anspruch 4 besteht, und

(b) einen im wesentlichen mikrowellenreflektierenden Deckelabschnitt, wobei der Deckelabschnitt zumindest teilweise an dem Bodenabschnitt der Verpackung angesiegelt ist, wodurch ein Raum entsteht, der das Nahrungsmittel aufnimmt.

10 11. Verpackung nach Anspruch 10, worin die Folie des Bodenabschnitts eine radiale Wulst um den Umfang des Nahrungsmittels herum nahe an der Höhe der oberen Fläche des Nahrungsmittels bildet und der Deckelabschnitt an der Wulst angesiegelt ist.

15 12. Verfahren zum Garen von Nahrungsmitteln, umfassend das Einbringen der Verpackung nach Anspruch 9, 10 oder 11 in einen Mikrowellenherd und das Betreiben des Herds über eine Zeit, die ausreicht, um das Nahrungsmittel in gewünschter Weise zu bräunen, knusprig zu machen und zu garen.

Revendications

20 1. Une structure stratifiée multicouche adaptable à une forme, utile pour emballer des aliments pour la cuisson aux micro-ondes, comprenant :

25 (a) au moins une couche de pellicule de matière plastique souple transparente aux micro-ondes, préparée à partir de polytéréphtalate d'éthylène, et qui résiste à une température d'environ 220 °C sans fondre ni se dégrader ;

(b) au moins une couche de pellicule de matière plastique souple transparente aux micro-ondes, préparée à partir de polytéréphtalate d'éthylène thermostable, et qui résiste à une température d'environ 220 °C sans fondre ni se dégrader, cette pellicule présentant en outre un retrait inférieur à 0,6 % lorsqu'elle est exposée pendant 30 minutes à une température de 150 °C ; et

30 (c) au moins une couche d'une matière sensible aux micro-ondes, sensiblement continue, disposée sur une surface d'une pellicule du stratifié, ladite couche étant située entre la pellicule (a) d'un côté et la pellicule (b) de l'autre côté, et étant présente en une épaisseur suffisante pour que la structure multicouche s'échauffe dans des conditions de cuisson aux micro-ondes jusqu'à une température convenant pour roussir ou rendre croustillants les aliments qui lui sont adjacents.

35 2. La structure multicouche de la revendication 1, dans laquelle l'épaisseur de la pellicule (b) est d'au moins environ 0,013 mm.

40 3. La structure multicouche de l'une ou l'autre des revendications 1 et 2, dans laquelle la matière sensible aux micro-ondes est un métal déposé sous vide.

4. La structure multicouche de l'une quelconque des revendications 1 à 3, comprenant, de plus, au moins une couche superficielle de résine thermoplastique soudable à chaud.

45 5. La structure multicouche de l'une quelconque des revendications 1 à 4, dans laquelle au moins une fente traverse la structure.

6. La structure multicouche de l'une quelconque des revendications 1 à 5, dans laquelle la pellicule (a) est également thermostable.

50 7. La structure multicouche de l'une quelconque des revendications 1 à 6, dans laquelle la couche de matière sensible est disposée sur la surface d'une troisième pellicule de matière plastique souple, transparente aux micro-ondes, résistante à la chaleur, placée entre les pellicules (a) et (b).

55 8. La structure multicouche de l'une quelconque des revendications 1 à 6, dans laquelle il y a plusieurs couches de matière sensible aux micro-ondes sensiblement continue, lesdites couches étant séparées entre elles par au moins une couche de pellicule de matière plastique souple, transparente aux micro-ondes, résistante à la chaleur.

9. Un emballage convenant pour contenir un aliment et roussir et rendre croustillante la surface de l'aliment dans un four à micro-ondes, comprenant la structure multicouche de l'une quelconque des revendications 1 à 8 enroulée autour de l'aliment.
- 5 10. Un emballage convenant pour contenir et cuire un article alimentaire dont les surfaces inférieure et latérales doivent être roussies et rendues croustillantes et dont la surface supérieure doit être protégée, ledit emballage comprenant
- 10 (a) un élément de fond adapté aux surfaces inférieure et latérales de l'article alimentaire, s'étendant jusqu'au niveau de la surface supérieure de l'article alimentaire, ledit élément de fond comprenant la structure multicouche de la revendication 4 ; et
- (b) un couvercle sensiblement réfléchissant pour les micro-ondes, ledit couvercle étant au moins partiellement scellé à l'élément de fond de l'emballage, en formant ainsi un espace pour contenir l'article alimentaire.
- 15 11. L'emballage de la revendication 10, dans lequel la pellicule de l'élément de fond forme un rebord radial autour de la circonférence de l'article alimentaire près du niveau de la surface supérieure de l'article alimentaire, et le couvercle est scellé au rebord.
- 20 12. Un procédé pour cuire un aliment, consistant à placer l'emballage de la revendication 9, 10 ou 11 dans un four à micro-ondes et à faire fonctionner le four pendant un temps suffisant pour que l'aliment soit roussi, rendu croustillant et cuit de la manière désirée.

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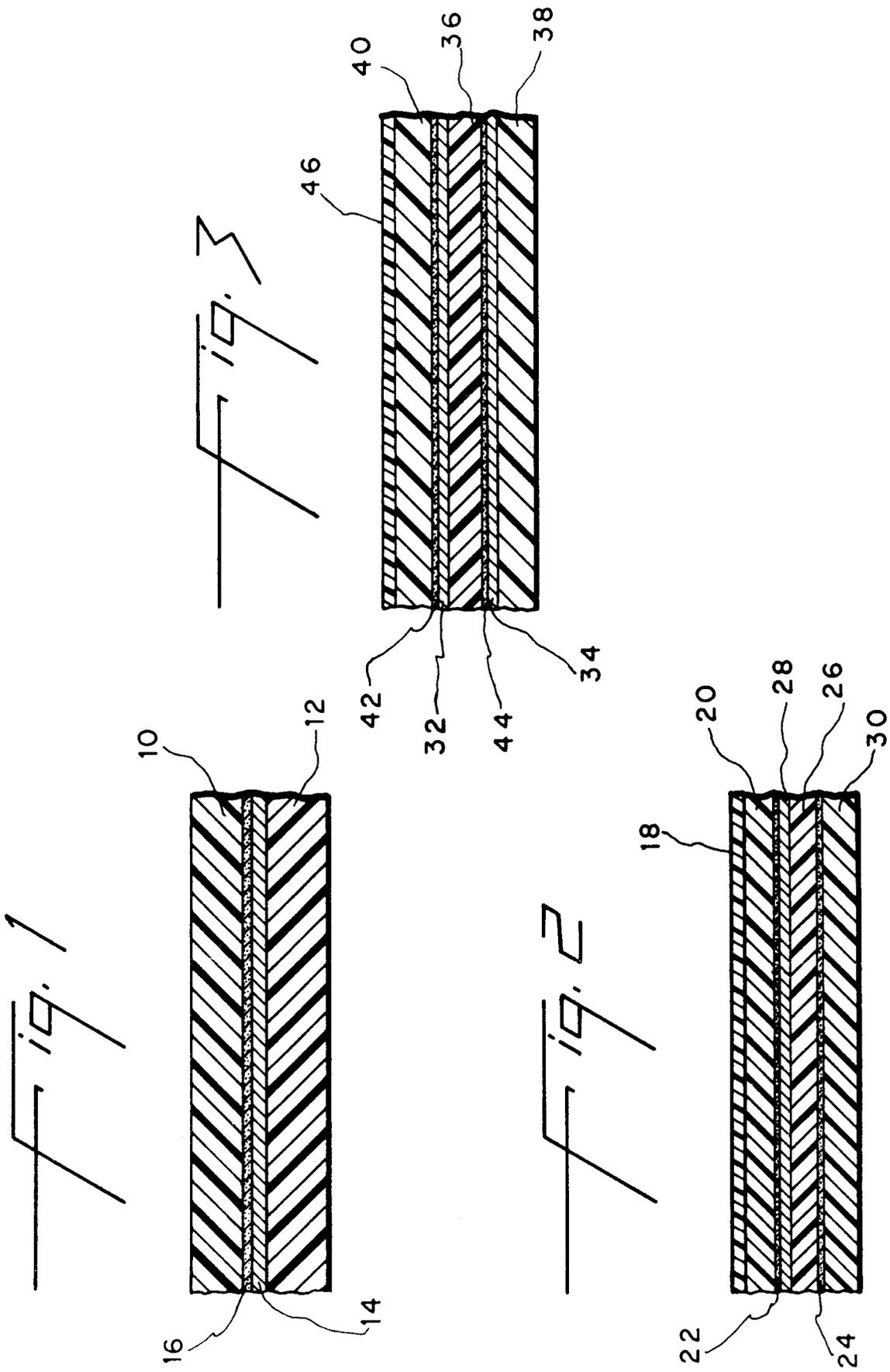
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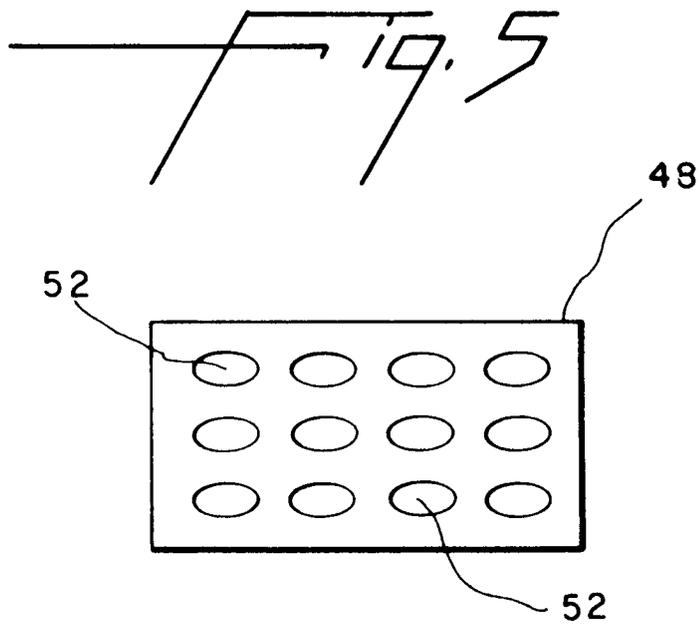
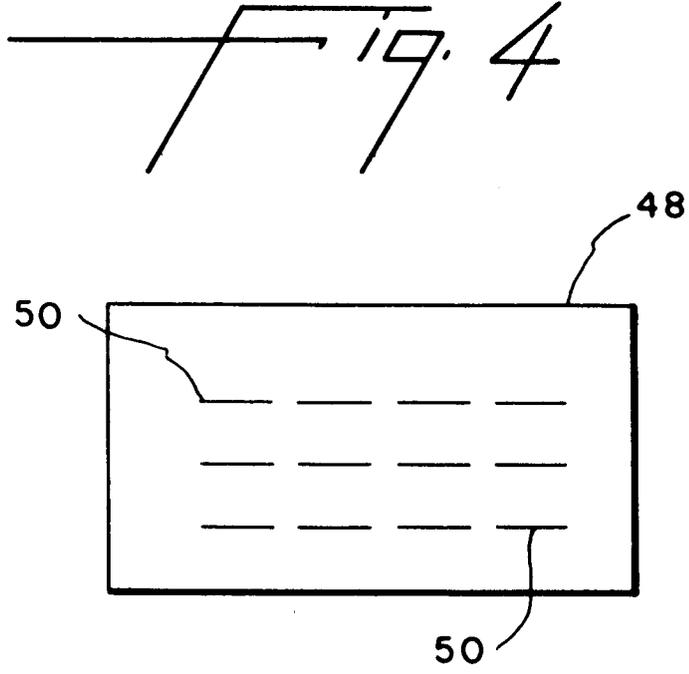


Fig. 6

